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# NREL's Alternative Fuel Transit Bus Evaluation Program

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Golden, Colorado

Windsor Workshop on Alternative Fuels  
Toronto, Canada  
June 5, 1996

*Center for Transportation Technologies and Systems*

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Sponsored by the U.S. Department of Energy  
Office of Transportation Technologies



# Participants

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- Battelle: Data collection and analysis
- University of Missouri: Data collection and analysis
- West Virginia University: Emissions testing
- Transit Sites
  - Bi-State Development Agency, St. Louis, MO
  - GP Transit, Peoria, IL
  - Houston Metro, Houston, TX
  - Metro-Dade Transit Authority (MDTA), Miami, FL
  - Metropolitan Council of Transit Operations (MCTO), Minneapolis/St. Paul, MN
  - Pierce Transit, Tacoma, WA
  - Triboro Coach Company (NYC DOT), New York, NY
  - Tri Met, Portland, OR

# Presentation Outline

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- Purpose of Program
- Program design
- Results
- Future direction

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**“Everything went quite well as long as  
a mechanic from Augsburg and an  
engineering school professor were  
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**An early diesel engine owner—late 1890s  
from: Diesel’s Engine by C. Lyle Cummins, Jr.,  
Carnot Press (distributed by SAE)**

# Purpose of Program

Perform unbiased, comprehensive evaluation of alternative fuels compared to diesel fuel in transit bus industry

- Reliability
- Cost
- Emissions
- Infrastructure/facility issues



# Purpose of Program *(continued)*

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## Alternative fuels

- E95/E93
- M100
- CNG
- LNG
- Biodiesel
- LPG (future)

# Program Design Targets

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- OEM production engines only
- Ten test buses of each technology, split between two sites
- Control and test buses have identical vehicle specifications, except for the alternative fuel
- Routes of control and test buses are similar or buses are randomly dispatched
- Cooperation of transit agencies

# Program Design

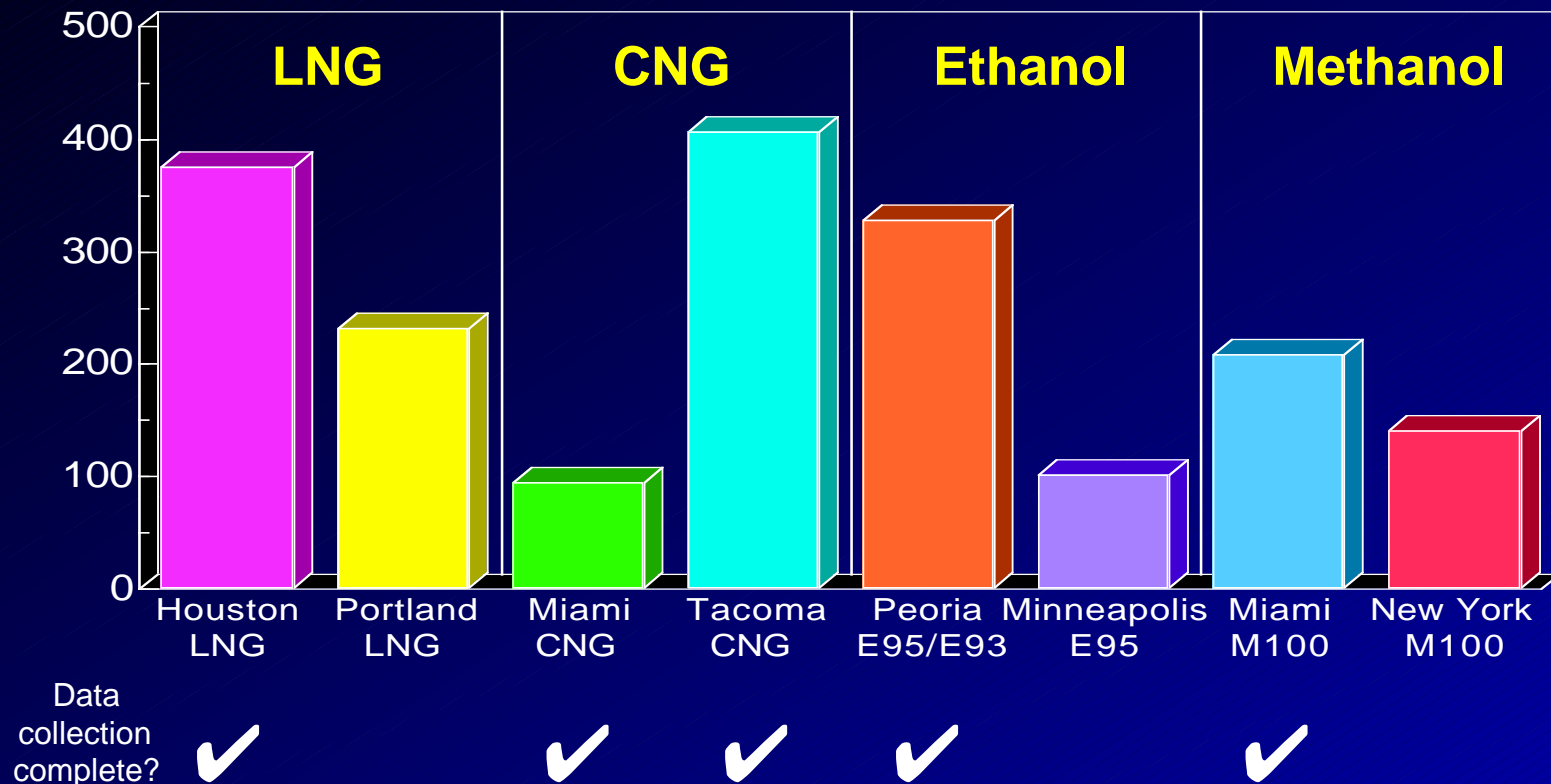
Agency	Engine	Technology								Total
		M100	E95	LNG PING	LNG Si	CNG Si	BD-20	DSL w/ Trap	DSL CNTRL	
Houston	DDC 6V92			10					5	15
Portland	Cum L10				8				5	13
Miami	DDC 6V92	5							5	10
	Cum L10					5		5	10	20
Minneapolis	DDC 6V92		5					5	5	15
Peoria	DDC 6V92		5					3		8
Tacoma	Cum L10					5			5	10
New York (Triboro)	DDC 6V92/ Series 50	5							5	5
									5	5
St. Louis	DDC 6V92						5		5	10
	Total	10	10	10	8	10	5	13	45	111

# Data Being Recorded

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- 18 months of data collection per site
- Fuel and oil additions
- All parts replaced/work done, except warranty
  - Parts replaced coded using ATA coding
  - Type of work done coded
  - Parts cost and labor hours
- Chassis dynamometer emissions  
(West Virginia University)

# Total Mileage on Alternative Fuel Buses (thousands of miles)



# Results

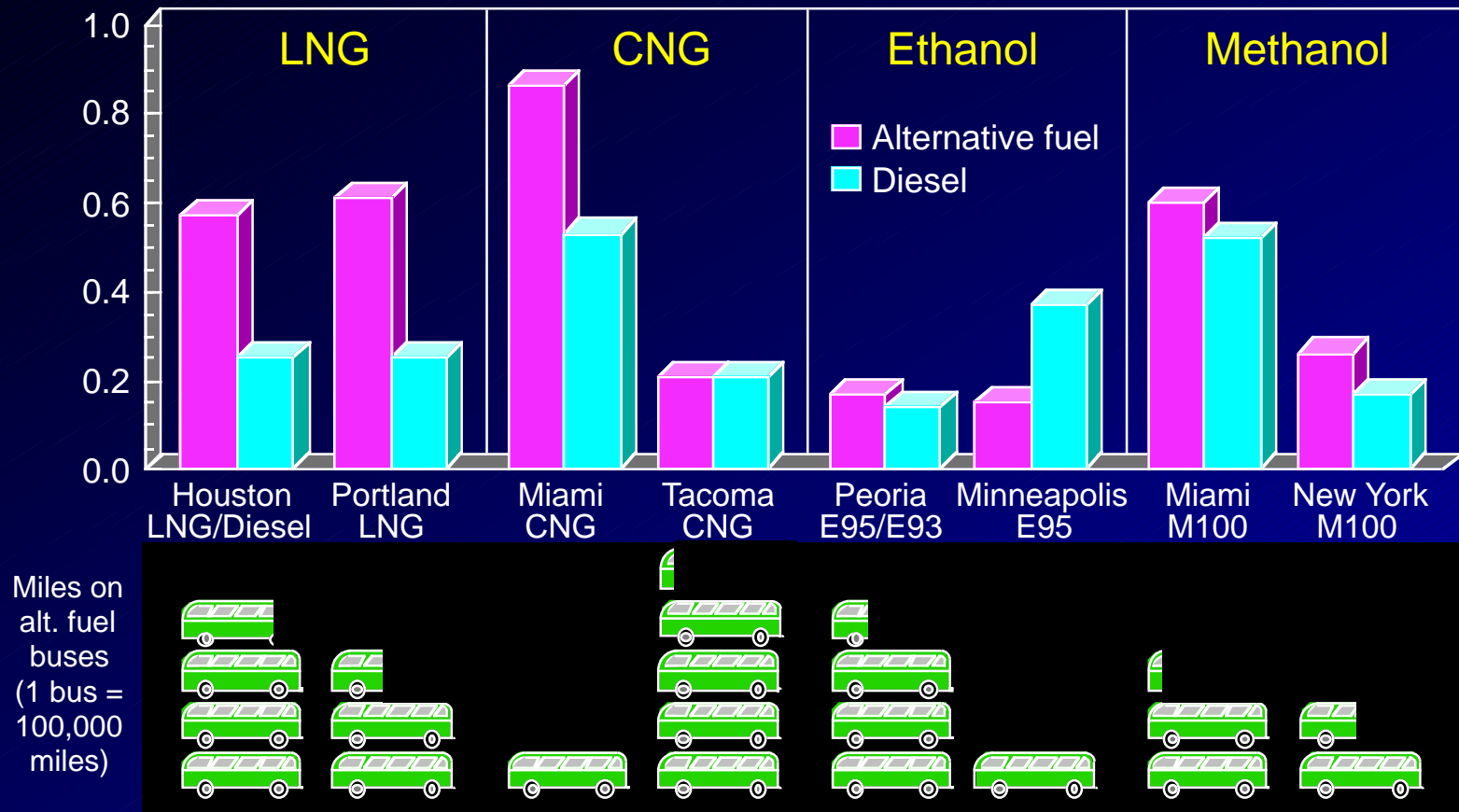
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- Reliability
- Operating Costs
- Emissions

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# Reliability

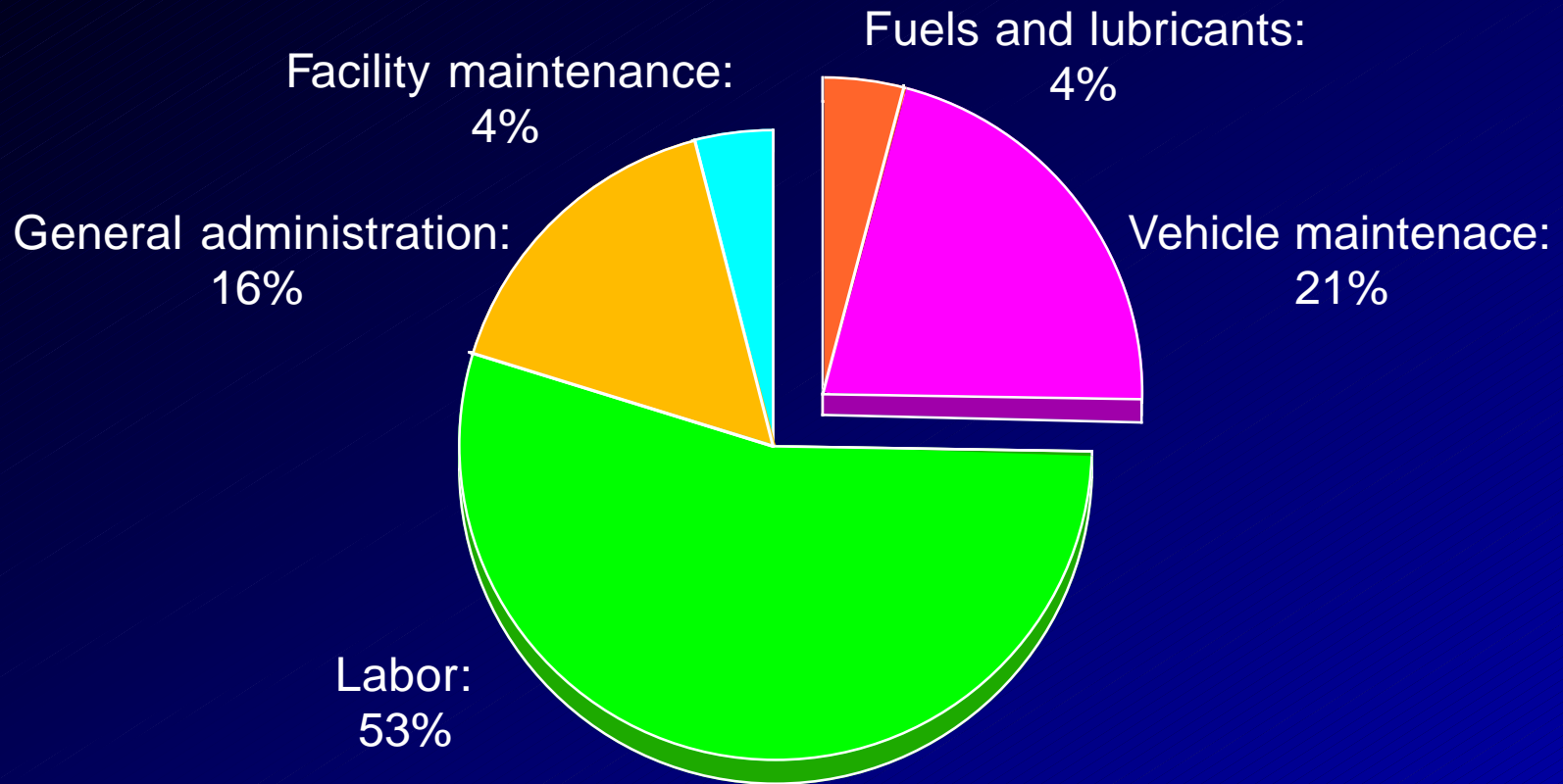
# Vehicle Reliability—Road Calls/1000 Miles



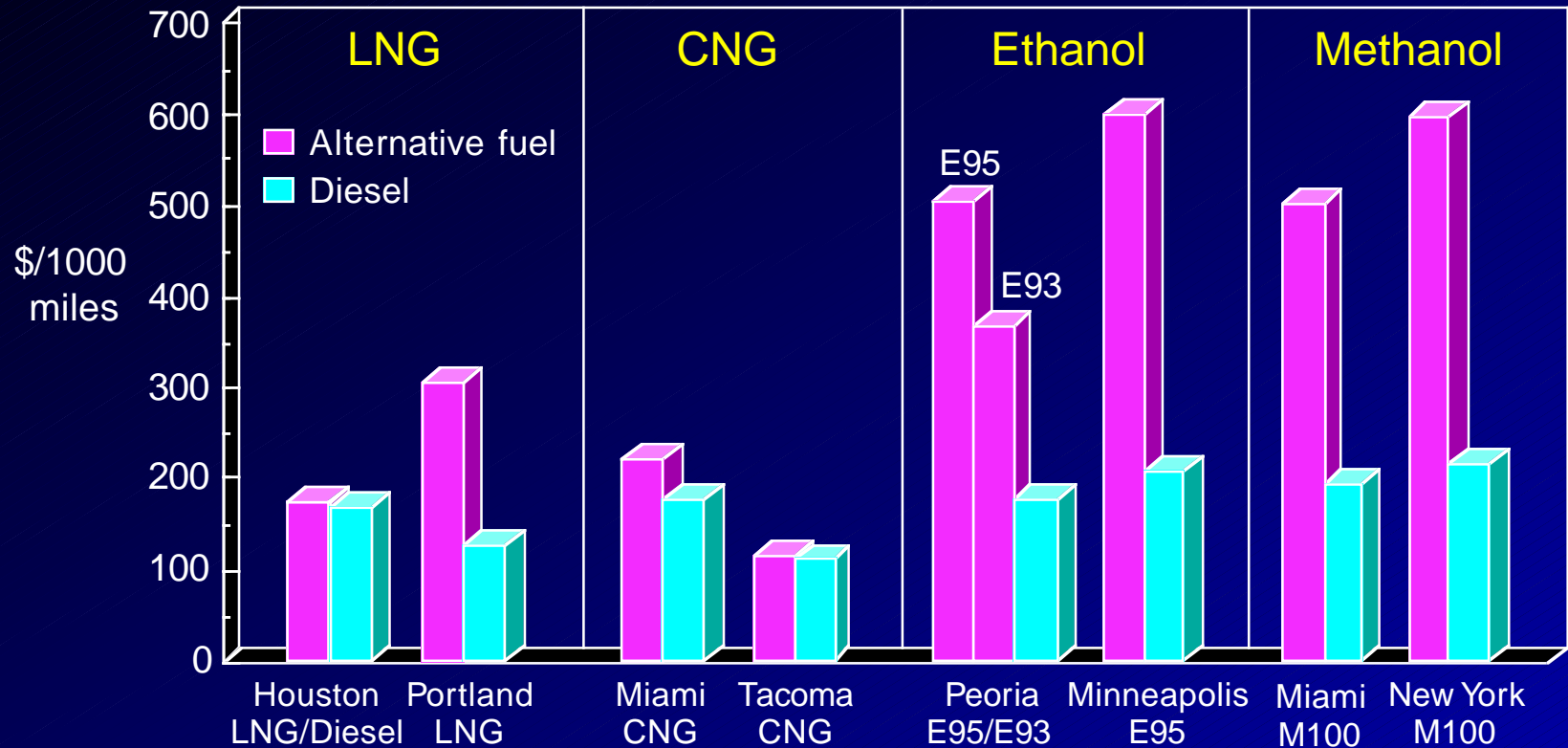
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# Operating Costs

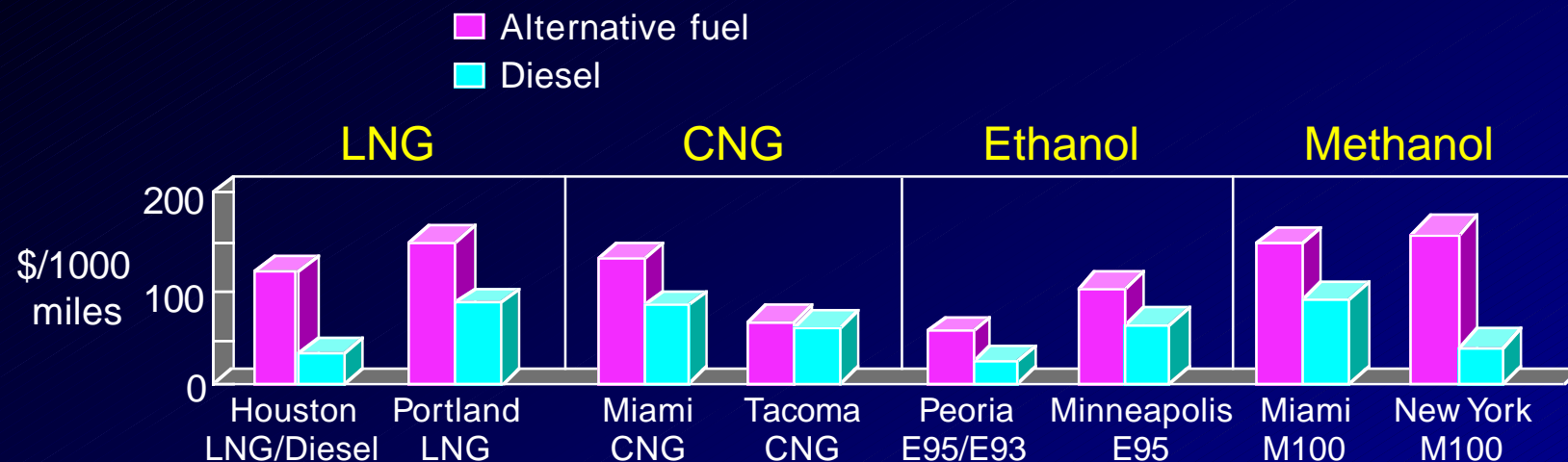
# Cost Breakdown for Transit Bus Operations



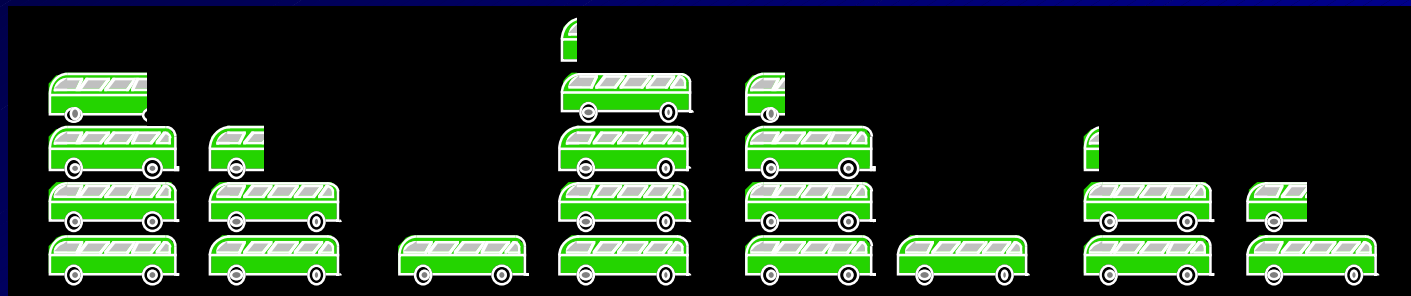
# Fuel Costs/1000 miles



# Maintenance Costs/1000 Miles (Alternative Fuel-Affected Systems Only)



Miles on  
alt. fuel  
buses  
(1 bus =  
100,000  
miles)



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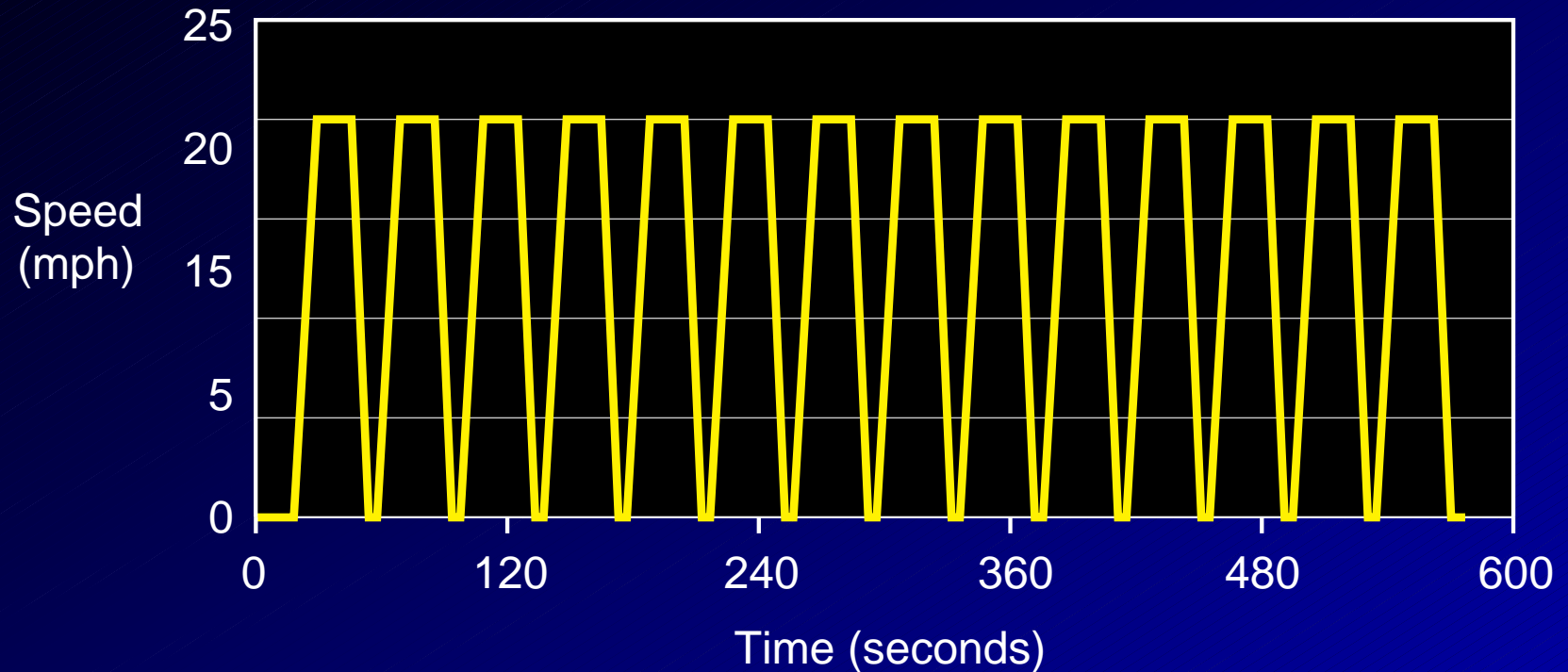
# Emissions Results

# Emissions Test Procedures

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- West Virginia University transportable **chassis** dynamometer
- Central Business District (CBD) test cycle
- Tested annually at transit site

# Chassis Dynamometer Test Cycle



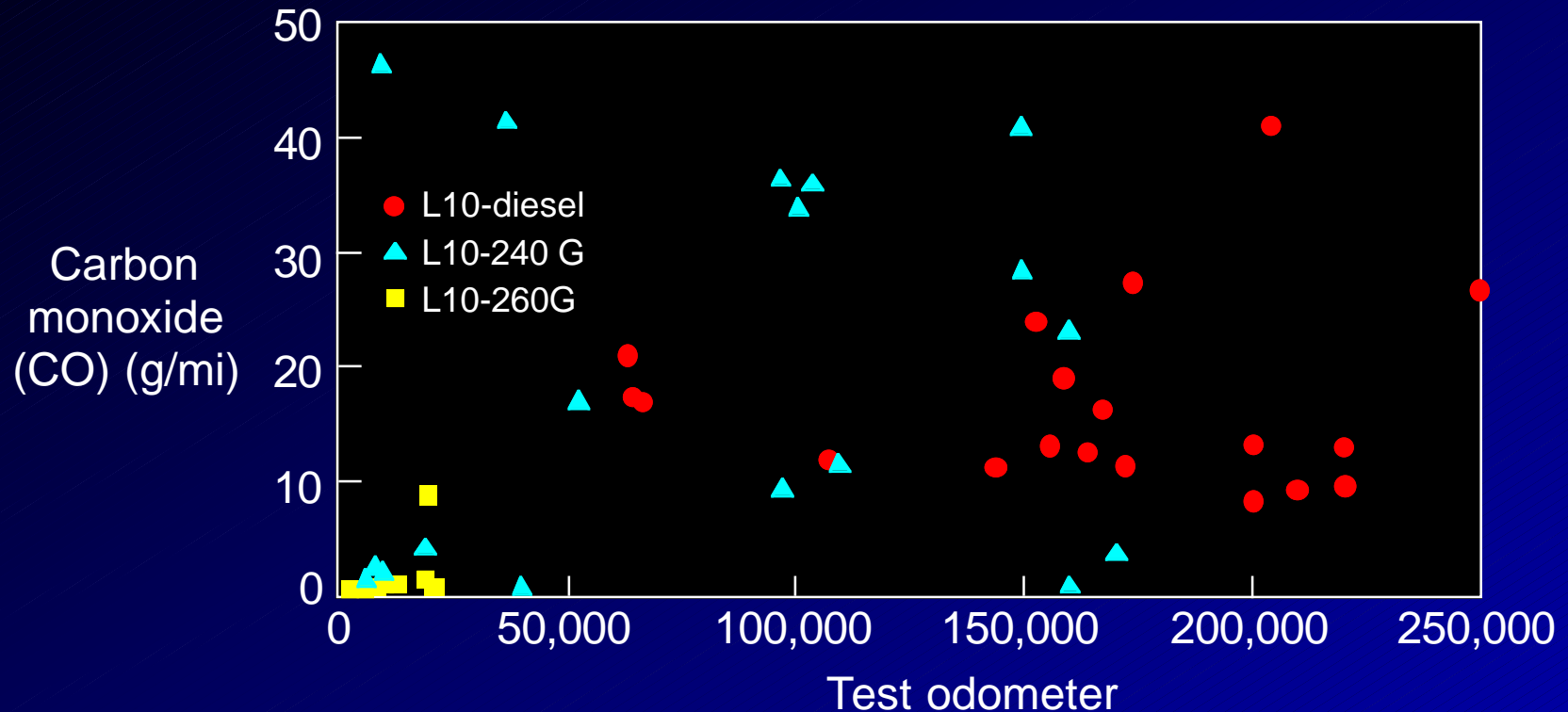


# Emissions Test Results

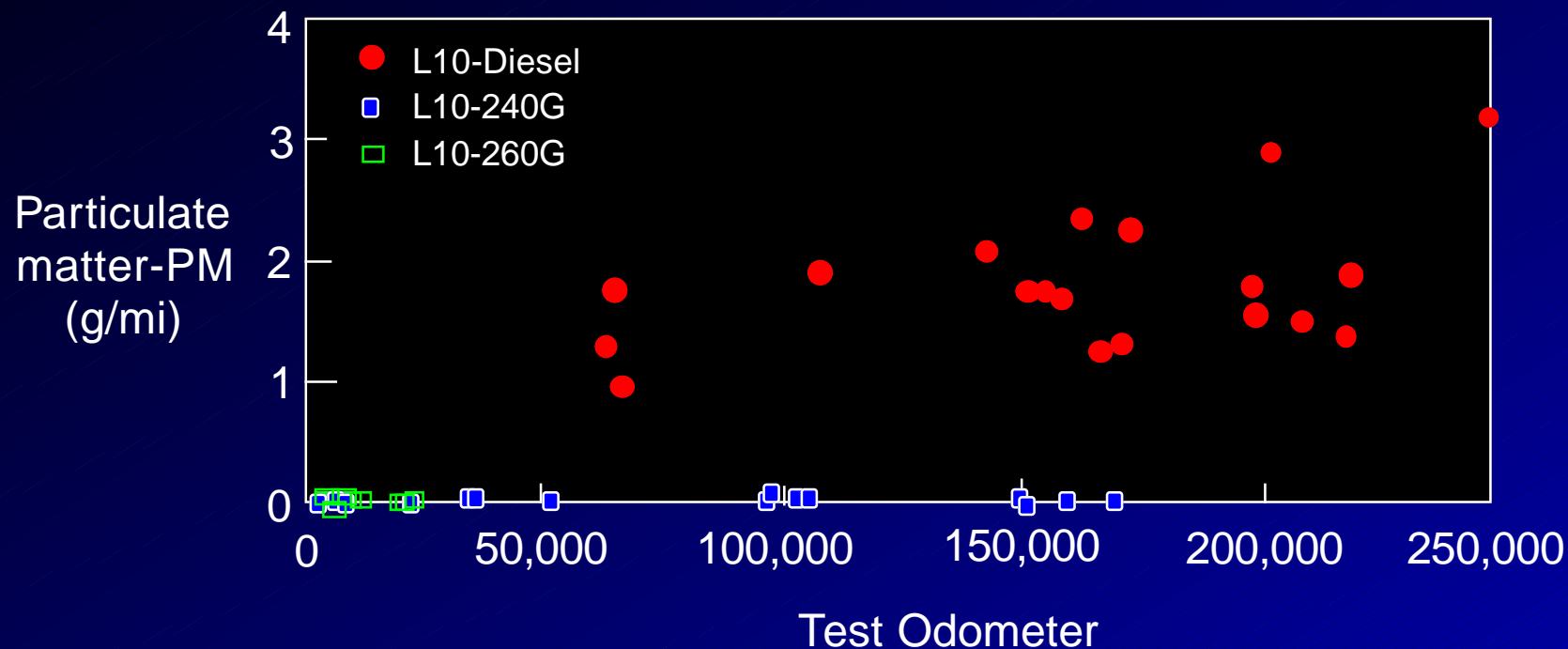
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- Unexpected chassis dynamometer results compared with engine dynamometer data
- Early generation alternative fuel buses have greater variability than diesel buses
- Working with OEMs to identify causes

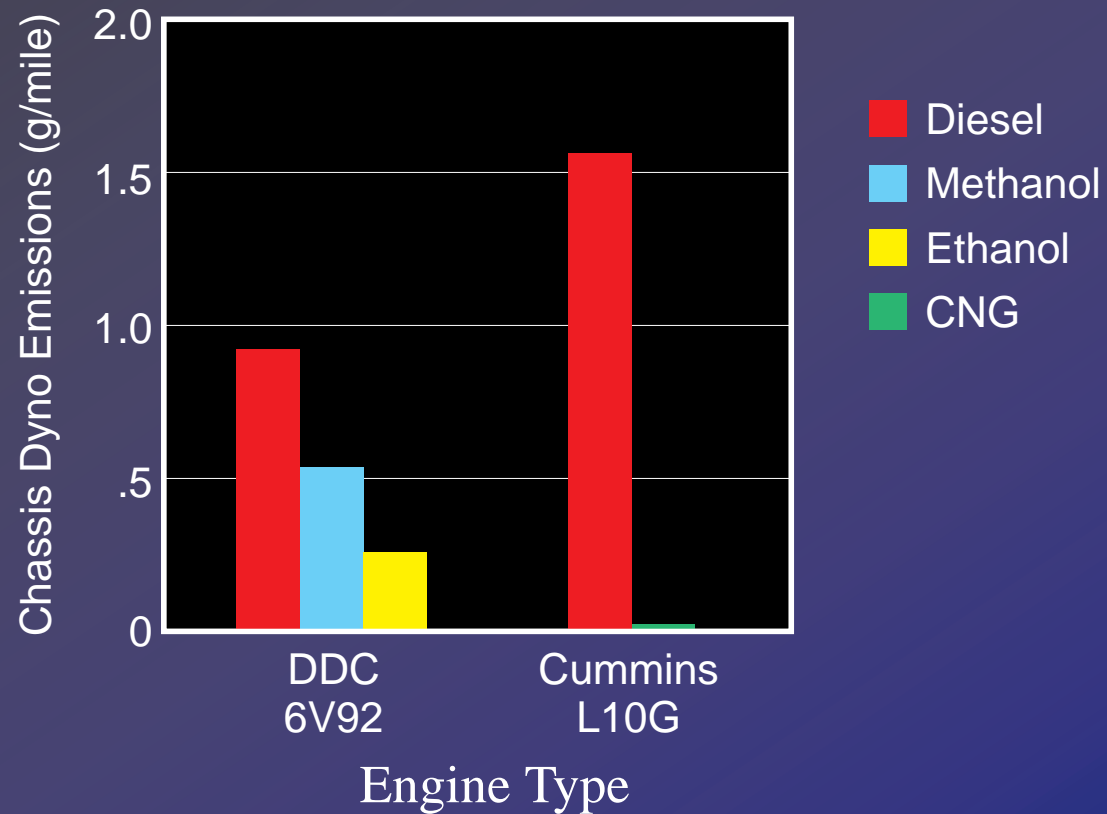
# Sample Emissions Results— Carbon Monoxide from CNG and Diesel Buses



# Sample Emissions Results— Particulate Matter from CNG and Diesel Buses



# Average Particulate Matter Emissions



# Emissions Test Results—Conclusions

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- Particulate matter emissions lower than diesel
- Alternative fuels have the potential to reduce other exhaust emissions
- Other factors are also very important
  - Technology level
  - Vehicle maintenance

# Some Program Conclusions

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- Bus reliability (road calls) generally comparable with diesel except for LNG sites
- Bus operating costs are driven by fuel costs
  - Operating costs comparable for CNG
  - Operating costs high for alcohols
- Bus capital costs opposite operating costs
  - High for CNG, low for alcohols
- Particulate matter emissions are lower than diesel
- More work needed on emissions

# Future Plans

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- Wrap up current sites by July 1996
- Produce Final Report
- Produce more detailed case studies of some sites
- Begin new study with the next generation of technology in 1997

# More Information

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- SAE Paper has more results than this presentation
- Final Report expected this summer
  - Call the National Alternative Fuels Hotline  
***1-800-423-1DOE***
- Visit our Web Site  
***<http://www.afdc.doe.gov>***